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FOREST PEST MANAGEMENT

BIOLOGICAL EVALUATION
R2-95-02

EMERGENCE AND OVERWINTERING BROOD OF DOUGLAS-FIR BEETLE SIX YEARS AFTER THE CLOVER MIST FIRE ON THE CLARKS FORK RANGER DISTRICT, SHOSHONE NATIONAL FOREST, WYOMING

JULY 1995

United States Department of Agriculture

Forest Service

Forest Pest Management
Denver, Colorado

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ABSTRACT

Two emergence peaks were evident for adult Douglas-fir beetles (DFB), *Dendroctonus pseudotsugae* Hopkins, collected from caged brood trees in 1994. The June peak resembled emergence patterns observed in previous years; however, an August peak was detected for the first time since monitoring of the outbreak began. The second peak likely resulted from delayed development of brood of the '93-'94 generation that largely overwintered as larvae. A portion of the '92-'93 generation also emerged in 1994, confirming that DFB can extend its life cycle to two years under certain conditions. The '93-'94 generation apparently also has developed an extended life cycle, resulting from the high percentage of immatures present in the overwintering brood of fall 1993. An average of 8.3 live DFB adults remained in fall 1994 beneath the bark of trees attacked in 1993. Many of these DFB adults are expected to survive another overwintering period to emerge in 1995.

Overwintering brood densities of the '94-'95 DFB generation averaged 17.1 per 36 sq. in. bark sample in October/November 1994. Brood densities were 57% higher than 1993 levels, but did not attain levels recorded in 1990 and 1992. Two-thirds of overwintering brood were adults, having returned to a more normal development pattern following two years of predominately immature overwintering broods. About 5 DFB survived to fall 1994 per attacking adult in infested trees, portending increasing populations given favorable weather conditions. Natural enemy populations varied by site, being unusually high at Sunlight Basin, moderate at Upper Reef Creek, and low at Camp Creek. The relatively high parasitism rate at Sunlight Basin likely contributed to lower brood densities of DFB present at that site compared to the other two sites.

The DFB population is expected to increase (up to five-fold) from 1994 to 1995, assuming normal winter temperatures, based on conclusions from brood data of the '94-'95 generation. However, unpredictable brood mortality between fall and spring would reduce the magnitude of actual population increase. DFB attack in 1995 is expected to be supplemented by delayed emergence of adults of the '93-'94 generation. Given favorable conditions, about a two-fold to three-fold population increase can be expected. Management alternatives to reduce the impact of the DFB epidemic are discussed.

INTRODUCTION

This evaluation is the sixth in a series that documents the progression of an outbreak population of Douglas-fir beetle (DFB), *Dendroctonus pseudotsugae* Hopkins (Coleoptera: Scolytidae) and the resulting tree mortality in the Cathedral Cliffs area of northwestern Wyoming (Pasek 1990, 1991; Pasek and Schaupp 1992; Schaupp 1993; Schaupp and Pasek 1995). Douglas-fir weakened by the Clover Mist Fire of 1988 provided the opportunity for resident DFB populations to increase; favorable conditions have allowed outbreak populations of DFB to persist in apparently healthy trees. A narrative summary follows.

The Clover Mist Fire burned onto the Clarks Fork Ranger District, generally south of U.S. Highway 212 and Wyoming Route 296 (Forest Route 100). In 1989, entomologists determined that large numbers of DFB were present in large diameter, blackened Douglas-fir trees (Pasek 1990). DFB brood production, measured in late fall of 1989 at the beginning of the overwintering period, was low to moderate. Most brood were in the callow adult stage, typical for this one-generation-per-year beetle.

By 1990 it appeared that an epidemic of DFB was developing in the area adjoining the fire boundary. Most, if not all, areas of large-diameter Douglas-fir adjacent to burned areas likely were infested by DFB in 1990 (Pasek 1991). Groups of DFB-killed trees also were evident in small pockets located at relatively short distances from the fire boundary, as well as on the upper east side of the Clarks Fork canyon, several miles distant. DFB were successfully attacking green, apparently healthy trees, as well as those scorched by fire. This movement of DFB from trees burned in 1988 into green trees also was documented elsewhere in the greater Yellowstone area (Amman and Ryan 1991).

Brood production increased dramatically in the '90-'91 DFB generation (Pasek 1991). The overwintering brood, consisting of about half immature and half callow adult stages, appeared healthy and few natural enemies were detected. A cursory examination of the brood in spring 1991 indicated very poor overwintering survival. The number of trees attacked in 1991 appeared to be similar to the number attacked in 1990.

Brood production decreased in the '91-'92 DFB generation to a lower density similar to that observed in 1989. Also similar to 1989 was the stage of overwintering brood, predominantly callow adults. Natural enemies of DFB were abundant, having built up on the persistent beetle population. DFB occupied green Douglas-fir only, because fire-scorched trees were no longer suitable or available. The number of trees killed by this DFB generation was about half as many as killed by the '90-'91 generation. A DFB population increase of 1.5 to 3 times was predicted for 1992.

Brood production increased in the '92-'93 DFB generation by about 3 times, returning to the high density level of the '90-'91 generation. Larvae comprised 79% of the overwintering brood, a greater percentage than noted in the '90-'91 generation. A population increase of 4-10 times was predicted for 1993, barring unusually high overwintering mortality.

Populations of adults emerging in spring and summer of 1993 were far less than expected based upon fall brood sampling of the '92-'93 DFB generation. This indicated possibly poor overwintering survival and/or a shift to a two-year life cycle, with some adults remaining beneath the bark for a second season. Overwintering brood densities of the '93-'94 DFB generation were 63% lower than 1992 levels, but similar to 1989 and 1991 levels. Atypical for DFB, most brood overwintered in the larval stage. Brood densities indicated a potential for up to a three-fold increase in population levels in 1994. However, many of the 1993 bark samples were unoccupied, indicating less than full utilization of the resource, and unsuccessfully attacked trees were noticeably abundant. Natural enemies were inconsistently and infrequently recovered.

The purposes of this evaluation were to predict the course of the DFB epidemic for 1995 and to document its progress while acquiring useful biological information on DFB. Activities included monitoring adult emer-

gence from trees infested by the '92-'93 and '93-'94 DFB generations, estimating overwintering population levels of the '94-'95 DFB generation, and examining stand and tree condition at several sites on the Clarks Fork Ranger District.

METHODS

On 4 May 1994, wire-mesh screen cages (1 by 2 ft.) were attached to the north sides of 13 standing, Douglas-fir that were infested by the '93-'94 DFB generation. Cages were located at two sites along Wyoming Route 296: Deadman Creek (6 cages) and Badger Spring (7 cages). Adult DFB that emerged under these cages were collected approximately weekly until 17 September 1994. Collected DFB were stored in alcohol and transported to the Rapid City Service Center office, where they were counted and their sex determined.

Additionally, two cages at each of three sites where cages had been attached in May 1993 (i.e., on trees infested by the '92-'93 DFB generation) were checked in the same manner. These cages were located at the K-Z Ranch, Camp Creek, and Deadman Creek. The intent of this effort was to determine whether DFB adults might emerge after remaining in trees through a second winter period.

On 26-27 October and 1-2 November 1994, bark samples (6 by 6 in.) were removed at a height of 5-7 ft. from the north and south side of each of 20 Douglas-fir trees currently infested by DFB. Sample sites were located at Upper Reef Creek, Sunlight Basin, and Camp Creek. DBH was recorded for each sample tree. Live DFB and DFB natural enemies dislodged from the bark sample during removal were identified, counted, and discarded. Number of gallery starts also was counted. Bark samples were stored in plastic bags and transported to the Rapid City Service Center office, where they were examined. Total inches of egg gallery was measured for each bark sample. Phloem was shaved with a knife to locate all remaining live insects in each sample. Numbers of live DFB brood were tallied by life stage and DFB natural enemies were counted. Means and standard deviations by sample site were calculated for all variables measured.
Using the same methods, bark samples were removed from several caged trees. Two trees caged in 1993 were sampled at the K-Z Ranch site. Of trees caged in 1994, three were sampled at Deadman Creek and four were sampled at Badger Spring. One sample was taken from under the caged area and the other from the opposite side of the tree. Bark samples were handled and examined as above.

RESULTS AND DISCUSSION

In 1994, adult DFB emerged from brood trees between late May and early September. Two peaks were evident, the first in June and the second in early to mid-August (fig. 1). The June peak resembled emergence patterns established in previous years (fig. 2). However, the August peak was detected for the first time since monitoring of the outbreak began. This second peak likely resulted from delayed development of brood of the '93-'94 generation that largely overwintered as larvae.

Wood (1982) described two principal flight periods for DFB -- an early flight in May/June from brood that overwinter as new or callow adults and a later flight in July/August both from late-developing brood that overwinter as larvae and from parent adults reemerging from their first set of galleries. The concentrated emergence of new adults that would lead to an early flight is well-documented (Furniss 1962; McMullen and Atkins 1962; Lessard and Schmid 1990). However, the cited authors observed neither a later, second flight nor emergence of new adults sufficient to result in such a flight. During emergence trapping in 1990, 1992, and 1993, the majority of DFB adults were collected in June, resulting in a single peak of emergence (Pasek 1991; Schaupp 1993; Schaupp and Pasek 1995). Apparently, the pattern of a single peak of emergence in spring is the most common occurrence, although a two-peak emergence pattern may occur in certain years.

In 1994, adult DFB emerged from all 6 trees that had been caged in May 1993 ('92-'93 generation). Most DFB adults emerged between late May and June; however, a few emerged in July, August, and early September.

Fig. 1. Douglas-fir beetle emergence by week of collection from 19 trees, each with a 1 X 2 foot cage, Cathedral Cliffs area, Wyoming, 1994.

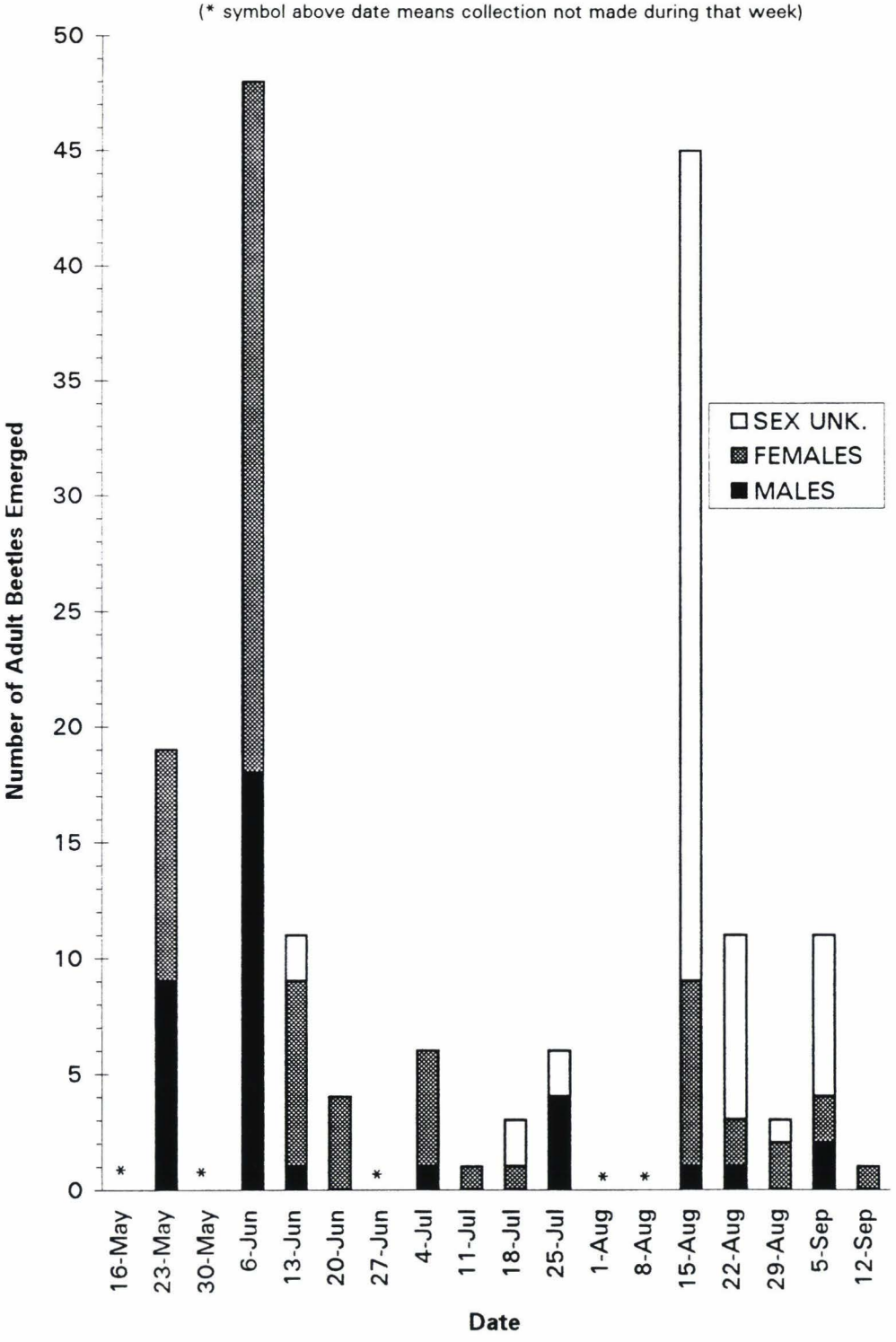
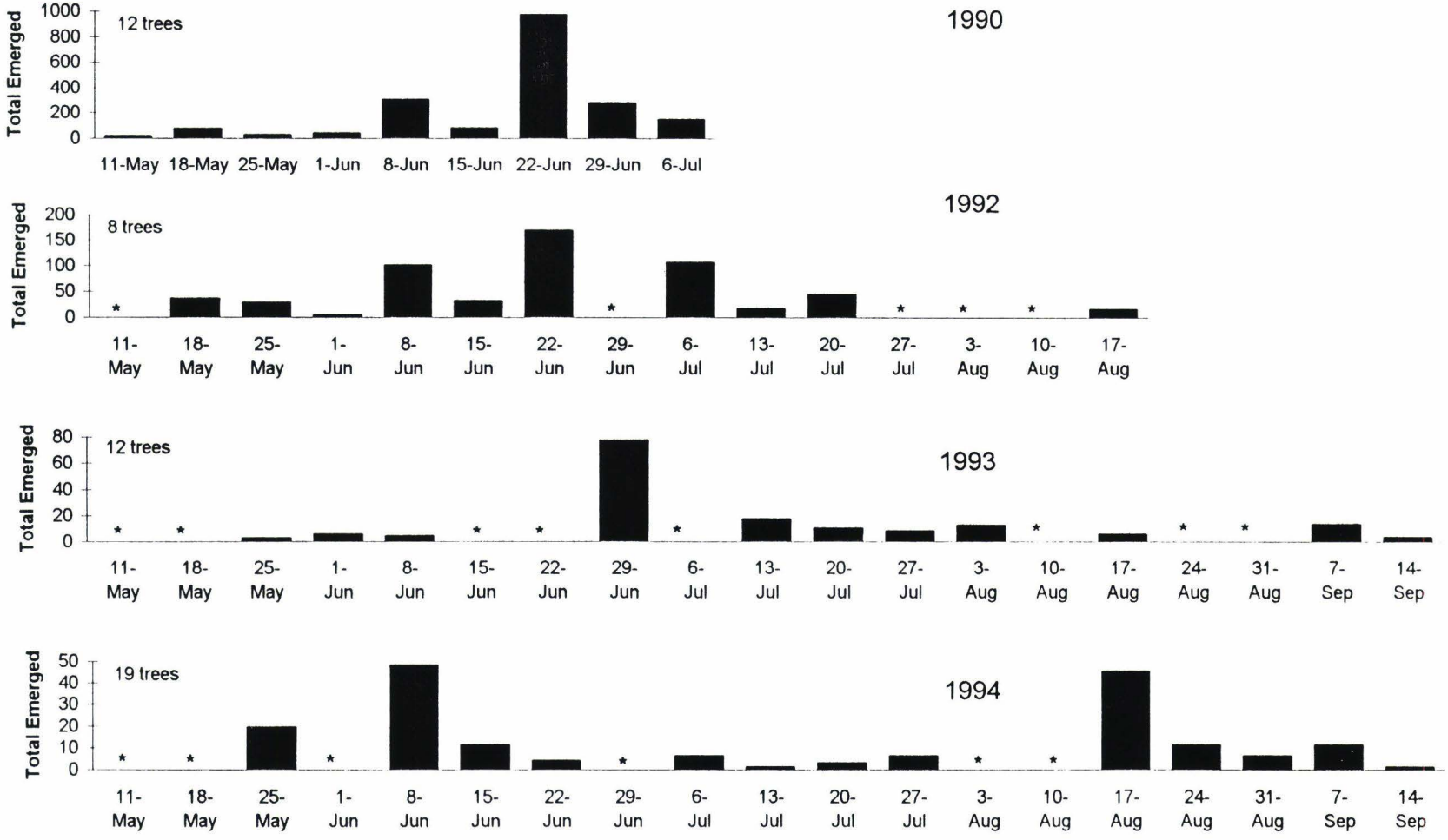


Fig. 2. Total weekly emergence of Douglas-fir beetles during 1990, 1992-1994, Cathedral Cliffs area, Wyoming, from 1 X 2 foot cage sections. A * symbol above date means collection not made that week.



The range of total DFB collected per cage was 1-20 adults or 0.5-10 DFB per square foot of bark surface. A total of 40 DFB adults were collected, for an average of 3.3 adult DFB emerging per square foot of bark surface (standard deviation = 3.6, n = 6 cages). Although emergence densities were low, these collections demonstrate that DFB can survive a second winter, extending their life cycle to two years. Such a shift likely resulted from delays in establishment, development of brood, and emergence caused by weather conditions. Combined with the average of 6.5 adult DFB per square foot that emerged in 1993 (Schaupp and Pasek 1995), brood production of the '92-'93 generation was approximately 9.8 DFB adults per square foot of bark surface. A preponderance of females was again found among those DFB emerging in 1994 (62%), similar to that found in 1993 (65%). No live brood were found remaining in fall 1994 beneath the bark of two caged trees sampled at the K-Z Ranch site.

For trees attacked in 1993 and caged in 1994 ('93-'94 generation), a total of 126 adult DFB were collected from emergence cages. This averages 4.8 adult DFB per square foot of bark surface using total DFB collected per cage over the entire trapping period (standard deviation = 3.0, n = 13 cages). The range of total DFB collected per cage was 0-18 DFB adults or 0-9 DFB per square foot. Approximately equal numbers of DFB were collected from the two sites: Deadman Creek and Badger Spring. More females emerged than males.

Not all DFB adults of the '93-'94 generation emerged in 1994. Live DFB adults were found in all three caged trees sampled at Deadman Creek and in two of four caged trees sampled at Badger Spring. An average of 8.3 live DFB per square foot of bark surface (standard deviation = 10.0, n = 14 samples) remained in fall 1994, much higher than that found remaining under the bark in the preceding generation. A life cycle extension likely will occur for the '93-'94 DFB generation due to the impact of the cool temperatures in the summer of 1993, which resulted in another predominantly immature overwintering brood (fig. 3) and delayed development of brood. Adults with delayed emergence can be expected to be active in spring and summer of 1995. In addition to live DFB adults, a number of live natural enemies were also found in samples from caged trees, especially at the Badger Spring site.

Population trend can be evaluated at the end of a generation by the ratio of beetles emerging from versus entering brood trees. This is calculated by dividing the density of emerging beetles by twice the density of gallery starts (attacks), assuming a pair of beetles initiates each attack. When the ratio of emergence to attack exceeds one, the population trend is increasing; when the ratio is less than one, the population trend is decreasing. For the '93-'94 DFB generation, the population trend was 0.30, indicating a declining population for the second consecutive year. This represents the approximately one-third of the surviving '93-'94 DFB generation that emerged and was available to initiate attack during 1994. This decline in population trend coincides with two consecutive years of brood that overwintered primarily in the immature stage (Fig. 3). Adult emergence was about 11% of the estimated overwintering brood, which was 79% immatures, for the '93-'94 generation. Attacks initiated in spring and summer of 1994 by the '93-'94 generation were likely supplemented by adults of the '92-'93 generation that delayed emergence until 1994; however, the combined populations still likely contributed to an expected decline in total attacks for 1994, which should be reflected in a lower number of trees infested in 1994 and fading in 1995.

High mortality among predominantly immature overwintering broods has been considered to contribute to the decline of epidemic DFB populations. Chansler (1968) found that a high proportion of larvae remaining among broods in the spring preceded a downward trend in a New Mexico infestation in two consecutive years. Furniss (1965) concluded that a long-term infestation in southern Utah subsided because of slow brood development, characterized by brood overwintering as immatures. McMullen (1970) also documented an extended life-cycle in DFB populations that overwintered as immatures and showed that adults from such extended populations produced as many or more brood than normal populations. He concurred with Furniss (1965) that extension of the life cycle to two years would tend to reduce populations through mortality occurring within trees.

For the '94-'95 DFB generation, overwintering brood density or mean brood production averaged 17.1 DFB per 36 square-inch sample or 68.4 per square foot of bark surface (Table 1). Brood density at the Sunlight

Fig. 3. Percentages of overwintering adult and immature Douglas-fir beetles from late fall samples of bark taken at 5-7 foot height from successfully attacked trees in the Cathedral Cliffs area, Clarks Fork Ranger District, Shoshone National Forest, Wyoming, for 6 years following the Clover Mist fire of 1988.

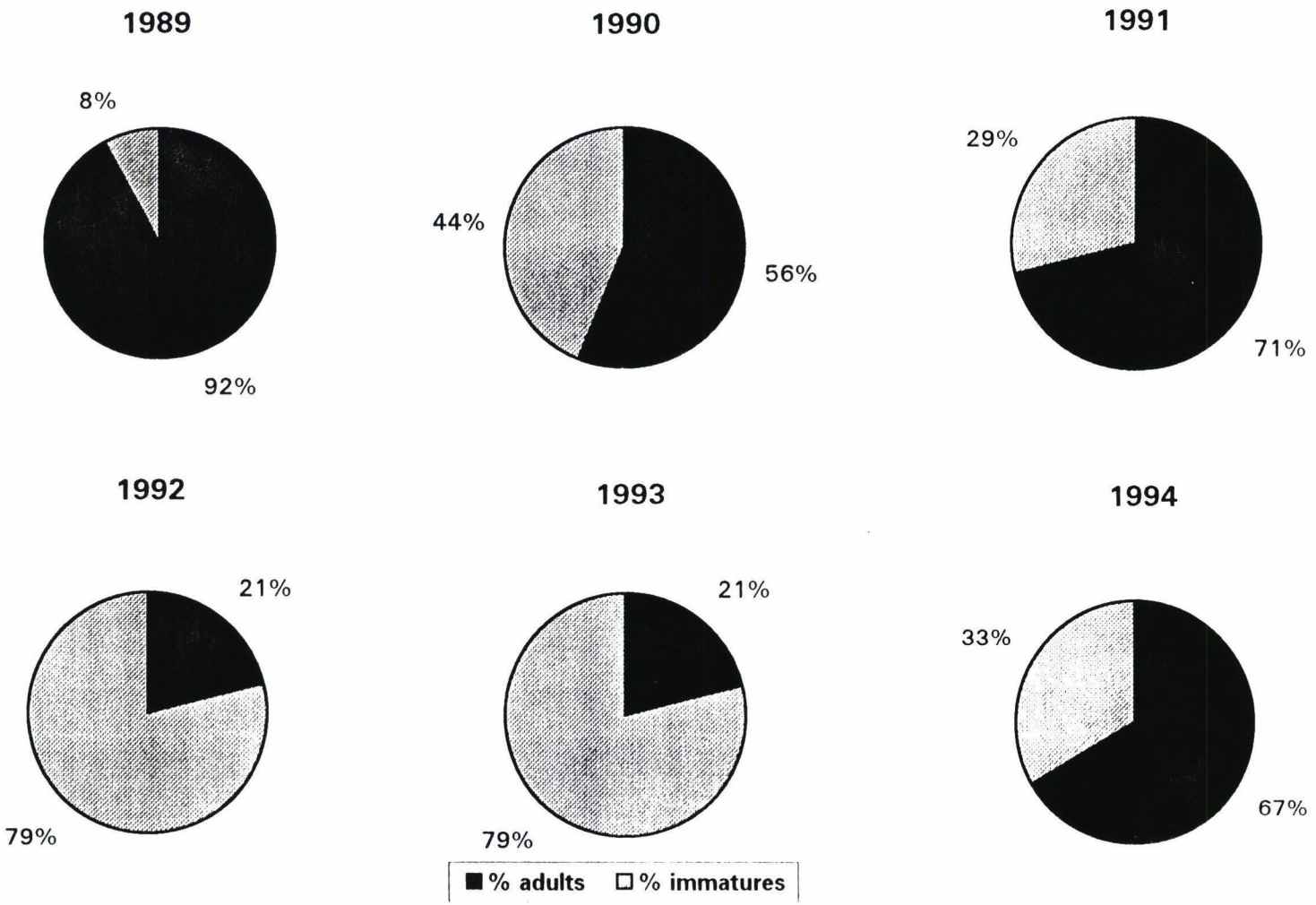


Table 1. Douglas-fir beetle overwintering brood production, gallery characteristics and natural enemy numbers per 36 square inches of bark surface of two samples per successfully attacked tree taken at 5-7 feet height in the Clarks Fork Ranger District, Shoshone National Forest, Wyoming, October 1994 (means + standard deviation).

	Aspect	Upper Reef Creek	Sunlight Basin	Camp Creek	All Sites
# Trees		15	2	3	20
DBH		22.9 ± 4.0	13.5 ± 2.8	21.0 ± 0.8	21.5 ± 4.6
Eggs	Both	0.0	0.0	0.0	0.0
Larvae	North	7.7 ± 12.1			6.8 ± 10.6
	South	5.3 ± 11.3			4.0 ± 9.6
	Both	6.5 ± 11.6	1.0 ± 1.4	6.3 ± 7.2	5.4 ± 10.1
Pupae	North	0.3 ± 0.9			0.2 ± 0.8
	South	0.5 ± 1.6			0.4 ± 1.3
	Both	0.4 ± 1.3	0.0	0.0	0.3 ± 1.0
Adults	North	10.7 ± 10.7			10.5 ± 10.2
	South	13.2 ± 11.9			12.3 ± 11.7
	Both	11.9 ± 11.2	8.8 ± 9.8	13.3 ± 14.0	11.4 ± 10.9
Total Brood	North	18.7 ± 12.0			17.5 ± 11.0
	South	19.0 ± 15.7			16.7 ± 15.0
	Both	18.8 ± 0.7	9.8 ± 10.8	19.7 ± 11.7	17.1 ± 13.0
Gallery Starts	North	1.8 ± 1.1			1.8 ± 1.0
	South	2.3 ± 0.9			2.3 ± 1.0
	Both	2.0 ± 1.0	2.0 ± 0.8	1.5 ± 0.8	2.0 ± 1.0
Egg Gallery Length	North	14.7 ± 7.5			15.2 ± 6.7
	South	14.5 ± 4.5			14.0 ± 5.3
	Both	14.6 ± 6.1	17.8 ± 5.9	11.0 ± 5.5	14.6 ± 6.0
DFB Enemies: Beetles	North	0.7 ± 2.1			0.5 ± 1.7
	South	0.0 ± 0.0			0.3 ± 1.0
	Both	0.4 ± 1.5	0.0	0.5 ± 1.2	0.4 ± 1.4
DFB Enemies: Wasps	North	2.7 ± 4.3			3.0 ± 5.6
	South	2.7 ± 4.9			3.0 ± 6.1
	Both	2.7 ± 4.5	11.3 ± 13.0	0.8 ± 1.2	3.0 ± 5.8
DFB Enemies: Flies	North	0.5 ± 0.9			0.3 ± 0.8
	South	0.4 ± 0.9			0.3 ± 0.8
	Both	0.4 ± 0.9	0.0	0.2 ± 0.4	0.3 ± 0.8

Basin site was about half that of the other two sample sites: Upper Reef Creek and Camp Creek. Only two sample trees showed signs of being less than fully attacked, unlike the high number of pitchouts observed in fall 1993 samples. Overwintering brood densities in fall 1994 samples increased 57% relative to fall 1993 samples, but did not attain the levels of 1990 and 1992 (fig. 4).

New or callow adults, the typical overwintering stage of DFB brood, comprised 66% of the life stages summarized in Table 1. Larvae were present in almost 2/3 of the samples, accounting for 32% of the life stages in all samples, while only 1% of the DFB brood was in the pupal stage. No eggs were found. The percentage of DFB overwintering in immature stages declined from the extremely high levels of the preceding two years (Schaupp 1993; Schaupp and Pasek 1995).

Samples averaged 2.0 gallery starts per 36 sq. in. (8.0 per sq. ft.) (Table 1), consistent with figures obtained in the preceding five years. Unoccupied areas were not apparent as had been the case for the previous generation. Attack densities found in the six years following the Clover Mist Fire on the Clarks Fork Ranger District were similar to those found to be indicative of increasing populations in trees > 10 in. DBH in the Rocky Mountains (Lessard and Schmid 1990). They are also on the high end of the range (4-8 attacks per sq. ft.) reported by McMullen and Atkins (1961) as being an indicator of maximum brood production. Assuming that one female and one male start each gallery, the density of gallery starts equates to 16.0 attacking DFB per square foot.

Mean total egg gallery length per bark sample varied by site ranging from 11-18 in. per 36 sq. in. (44 - 72 in. per sq. ft.) (Table 1). These gallery densities overlap the range of 30 - 60 in. per sq. ft. that reportedly represents maximum brood production levels (McMullen and Atkins 1961).

Presence of parasitic wasps of DFB were exceptionally high in samples at the Sunlight Basin site, averaging 11.3 wasps per 36 sq. in. of bark surface or 45.2 per sq. ft. (Table 1). This high parasitism rate likely accounts for the lower DFB brood production levels at this site compared to the other two sample sites. Parasitism levels were moderate at the Upper Reef Creek site and low at the Camp Creek site.

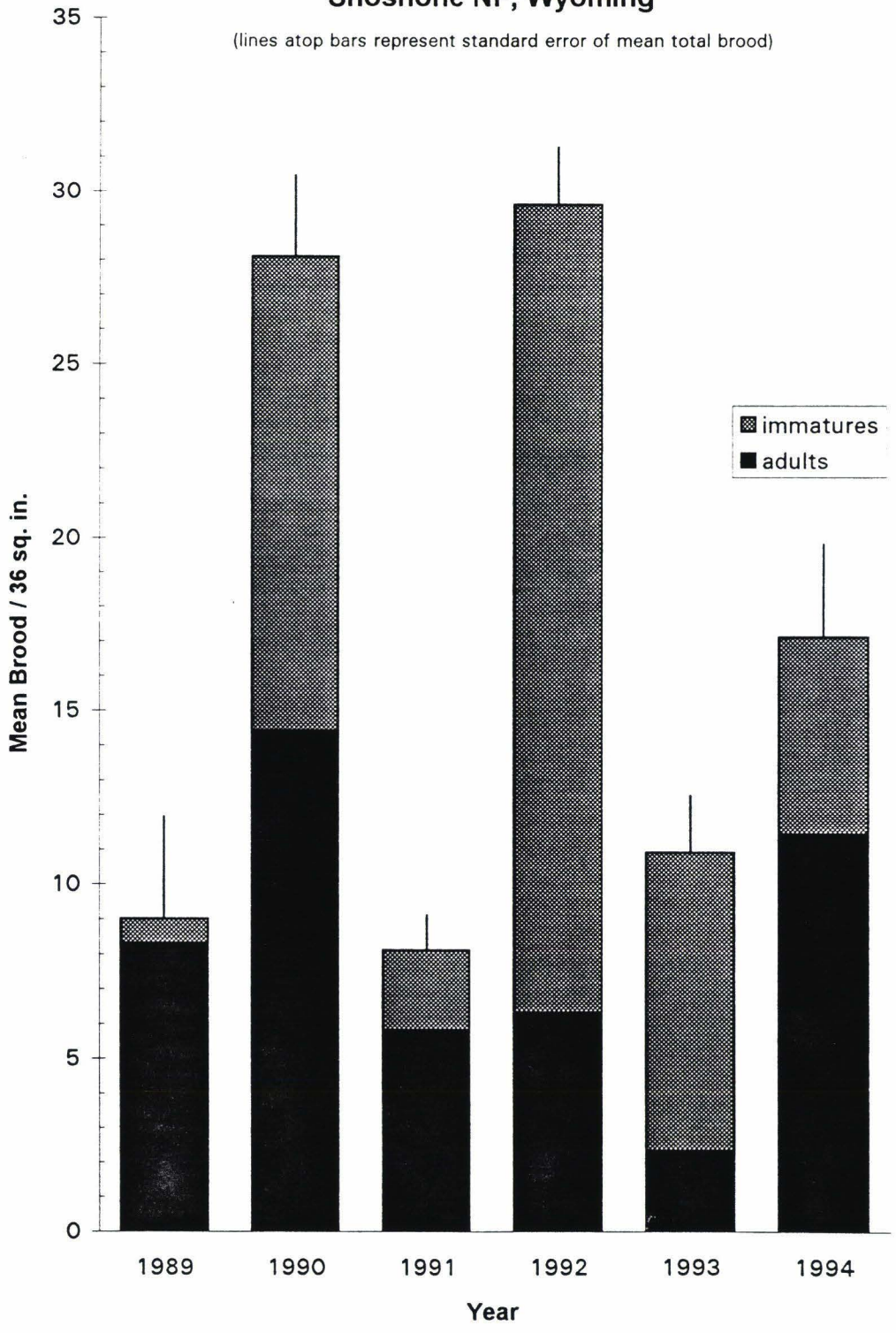
The number of DFB brood per attacking adult, calculated as the average density of total brood divided by twice the average density of gallery starts, can be used as an index of population change. For the '94-'95 generation, this population index forecasts an increase ranging from 2.4 to 6.6 times by site, with an overall weighted average of 4.8 times. Before the fall DFB brood matures and attacks other trees the following summer, biotic and especially abiotic mortality factors further reduce the population size. The magnitude of this mortality is unpredictable and strongly influences population size in the subsequent beetle generation. Given that 2/3 of the overwintering population is in the adult stage, overwintering survival of brood can be expected to be good provided overwintering weather conditions are mild or normal. A population increase should be reflected in greater numbers of trees being attacked in 1995, given that attack densities have remained relatively constant throughout the course of the current epidemic. Additionally, the delayed emergence of adults of the '93-'94 DFB generation is expected to increase the number of DFB adults attacking trees in 1995. Given favorable conditions, about a two-fold to three-fold increase in DFB population can be expected for 1995. This suggests a reversal of the apparent decline in population levels of the preceding two years and indicates that the DFB epidemic has not yet collapsed.

ALTERNATIVES

Several methods are available to reduce populations of DFB and the resultant tree mortality. These pest management strategies may focus on the reduction of infested material, reduction of susceptible host material, or prevention of new attacks. The decision to use a particular method should be predicated on considerations of stand conditions, location, management objectives, economics, social values, and other factors.

Fig. 4. Douglas-fir beetle, overwintering brood by year, Clarks Fork District, Shoshone NF, Wyoming

(lines atop bars represent standard error of mean total brood)



Alternative 1:

Sanitation Harvesting - Fell infested trees and remove them from the site for mill processing prior to adult DFB emergence. Stands with the highest percentages of large-diameter Douglas-fir should be given priority.

Where to use - Sites with the following conditions are appropriate: accessible to logging operations such as near existing roads or where roads can be readily constructed; less than 40% slope; where human disturbance will not adversely affect special resource values; and in proximity to high value areas that need to be protected.

Advantages - Beetle broods can effectively be eliminated in small, isolated loci by removing all infested trees prior to beetle emergence. Beetle populations in larger groups can be significantly reduced. Sanitation harvesting provides a degree of protection to surrounding, uninfested trees by removing a nearby source of attacking beetles, recovers timber volume that otherwise would be lost, reduces fuel load, reduces subsequent hazard from falling trees and inaccessibility to large animals, reduces visual impact of dead and dying trees, and will encourage regeneration and greater diversity of size and age classes across the forest.

Disadvantages - Short implementation time is required; trees must be removed prior to adult emergence in the spring following attack. Adverse disturbance of the site and soil is possible. Sanitation harvesting may remove tree cover in spots or at a density considered adverse aesthetically.

Alternative 2:

Tree Baits - Commercially available DFB tree baits containing attractant semiochemicals (aggregation pheromone) can be used to concentrate beetles in trees that can be subsequently harvested. Baits are deployed just prior to beetle flight (May) and baited trees must be felled and removed or destroyed prior to the next adult emergence period (i.e., within one year).

Where to use - Ideal sites for placement of baits would be Douglas-fir trees in and around salvage operations. Baited areas must be suitable for harvest (Alternative 1) or mechanical control (Alternative 3). Baiting is likely to be most effective in areas where beetle populations are small; e.g., it is useful as a mop-up operation following removal of infested trees. Baiting is not suitable for large population centers; the native beetle population quickly overwhelms the baits in this situation.

Advantages - Baiting may provide some degree of redirection of beetle attacks to trees where salvage can be implemented. Beetles emerging from infested trees that were missed during salvage harvesting in one year may be concentrated in logs or trees for removal the following year.

Disadvantages - Application is generally limited to sites accessible to harvest and where beetle populations are low and relatively isolated from larger population centers.

Alternative 3:

Mechanical Control - Fell and buck infested Douglas-fir trees and treat them by burning, peeling the bark, or chipping the logs.

Where to use - Use in unroaded areas or on steep slopes that are accessible on foot (or horseback) to logging but where road building or skidding is undesirable. Sites where no

logging company is interested in bidding on the timber or volume is too small to put up a sale also are appropriate.

Advantages - Much of the beetle brood can be eliminated from small pockets even in the absence of a timber market. Mechanical control provides a degree of protection to surrounding, uninfested trees by removing a nearby source of attacking beetles. It also reduces subsequent hazard from falling trees and inaccessibility to large animals, reduces visual impact of dead and dying trees, and will encourage regeneration and greater diversity of size and age classes across the forest. Potential for site and soil disturbance is less than for Alternative 1.

Disadvantages - Mechanical control is labor intensive, does not recover value and volume from trees, leaves a high fuel load on the site, removes tree cover, and requires a short implementation time; trees must be treated prior to adult emergence in the spring following attack. It is not effective where large populations are present in adjacent areas.

Alternative 4:

Trap Trees - Green trees can be felled and left on the site to attract beetles. Felled logs are sprayed with carbaryl in April or May, just prior to the beetle attack period, so that beetles will be killed as they enter the logs. Tree baits can be used on felled logs to increase their attractiveness to beetle attack.

Where to use - Use in small infestation pockets where salvaging, mechanical control, or reentry is impractical. Also use in unroaded areas or on steep slopes that are accessible on foot (or horseback) to logging but where road building or skidding is undesirable. Sites where no logging company is interested in bidding on the timber or volume is too small to put up a sale also are appropriate. Trap trees may be used as a tool to mop-up a population following salvaging.

Advantages - Use of trap trees concentrates beetle attack away from trees where protection is desired, kills beetles, does not require sale preparation and administration, can be used on sites with steep slopes or where roads do not exist and are not desirable, and is not as labor intensive as mechanical control.

Disadvantages - Use of trap trees does not recover value and volume from trees, leaves a high fuel load on the site, and removes tree cover.

Alternative 5:

Silvicultural Treatment - To reduce susceptibility in green stands, basal area should be reduced below 80% of normal stocking (Furniss et al. 1981). Mature and old stands of Douglas-fir can be harvested. Younger stands should be thinned periodically to improve vigor and reduce moisture stress.

Where to use - This is a preventative treatment that should be considered as an ongoing part of the regular timber program. Due to limited staffing and funding, this alternative may not be feasible during an epidemic where resources are better spent on other options.

Advantages - Silvicultural treatment reduces susceptibility of stands to beetle attack, which may limit tree mortality and infestation size in the event of a future increase in beetle population.

Disadvantages - This alternative is not suitable for sites where harvesting activity is not desirable, such as in wilderness, on steep slopes, or where visual quality would be adversely impacted.

Alternative 6:

Protection of High Value Trees - Prior to beetle flight in early spring (April or May), the boles of valuable trees can be sprayed with carbaryl to prevent DFB attack.

Where to use - This method would be appropriate for use in and around campgrounds and private homes. Trees must be of high value. Insecticide application is not effective for trees that have already been infested.

Advantages - Insecticide application provides a degree of protection not currently available through other mitigation strategies. Carbaryl has a low mammalian toxicity and low residual activity, which means it remains in the environment for a short period of time.

Disadvantages - Efficacy for protection of Douglas-fir needs to be demonstrated by a test prior to operational usage. Material is toxic to other insects as well as to DFB. Many citizens have concerns about environmental contamination and safety. Insecticide application does not effectively reduce the existing beetle population, is expensive if very many trees are treated, and size of treatment areas need to be small due to cost and labor considerations.

Alternative 7:

Repellents - A granular controlled-release formulation of the DFB antiaggregative pheromone, 3-methyl-2-cyclohexen-1-one (MCH), can be broadcast or aerially applied to stands where protection is desired. This alternative currently requires an experimental use permit, because registration of the material with EPA is not yet completed.

Where to use - The method is most suited for high value and inaccessible stands that are not currently infested but are threatened by nearby beetle populations.

Advantages - MCH is nontoxic; it is a natural chemical that is produced by DFB. Use of MCH is a promising method of preventing new attacks.

Disadvantages - MCH does not directly reduce the existing beetle population. Granular application distributes plastic pellets into the environment. Availability of the material may be a problem. MCH is not yet registered and has not been tested to determine the efficacy for protection of standing, green trees.

Alternative 8:

Do Nothing - Accept tree mortality caused by DFB as a natural phenomenon.

Where to use - Use where other control alternatives cannot be effected or are not desired. This may be the only viable alternative for infested stands that are inaccessible, areas designated as Wilderness, and sites where the visual and erosive impacts of harvesting are a major concern.

Advantages - No unnatural site disturbance or introduction of foreign materials into the environment will occur. Change in vegetation follows a natural event.

Disadvantages - The no action alternative allows the beetle population to continue to increase and threaten additional sites. Tree volume and value is lost, visual quality is adversely affected by dying and dead trees, fuel load increases, tree hazard increases, inaccessibility to large

animals increases with time as trees fall over, and tree regeneration is inhibited due to shading by remaining dead trees and lack of seedbed preparation.

RECOMMENDATION

Emphasis should be placed on long-range management planning to increase the health of forest stands and reduce susceptibility to DFB attack (Alternative 5). This is particularly appropriate for stands in the suitable timber base where emphasis is placed on timber production and for areas where loss of tree cover is undesirable. Priority for silvicultural treatment should be given to older, dense stands of predominantly Douglas-fir composed of large diameter (> 16 inches DBH) trees. Within a couple years, Forest Health Management staff expect to develop a stand risk/hazard rating system for DFB that can serve as an aid to prioritizing stand treatments and assessing effects of various management alternatives.

Removal of currently-infested trees (Alternative 1) should be incorporated into any harvesting or thinning operations, to further reduce DFB populations in the immediate vicinity. This alternative is appropriate for stands being managed to improve long-term sustainability (Alternative 5) and for stands where tree losses are imminent and a reduction in DFB impact is currently desirable.

Alternative 4 may be appropriate where baits can be used to lure residual DFB populations to log decks for subsequent removal. Successive baiting and sanitation harvesting may be needed using this method.

DFB populations likely are still too high for Alternative 2 to be effective. The natural pheromone of the beetles may overwhelm artificial baits attached to standing, green trees such that infestation spreads beyond the intended area. This alternative is not recommended at present.

Alternatives 3 and 6 may be useful for treating or protecting high value sites, such as campgrounds or homesites.

Alternative 8 may be selected of necessity in much of the Clarks Fork Ranger District because of extensive areas of Wilderness affected by the Clover Mist Fire, concerns for the protection of certain wildlife species, the presence of inaccessible areas, the concern for visual and erosive impacts of harvesting options, and the constraints on time and personnel available to treat infested sites.

Land managers need to develop site-specific plans to manage stands relative to anticipated effects of DFB in relation to desired conditions and resource objectives stated in a Forest Plan. Alternatives should be weighed in relation to site-specific characteristics.

Forest Health Management personnel will continue to assist in reassessing DFB populations and DFB-caused tree mortality as needed during the course of the infestation.

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